

CLAIMS

1. A method for reducing stress in an electrical network, in which method an inrush current caused by a network component or part connected to the live electrical network is minimized, the network component or part being disconnected from and connected to the live electrical network by opening and closing a circuit breaker, the method comprising

measuring the current of at least one phase of the network component or part,

determining the breaking-off moment of the current after the circuit breaker is opened,

determining an optimum closing moment of the circuit breaker on the basis of the breaking-off moment of the current, and

closing the circuit breaker in such a manner that it closes at the optimum closing moment.

2. A method as claimed in claim 1, wherein the electrical network is a three-phase network, the circuit breaker is a triple-pole circuit breaker, the currents of all three phases are measured, and the breaking-off moment of the current is one common computational breaking-off moment of the currents of all phases.

3. A method as claimed in claim 2, wherein the common computational breaking-off moment of the currents is a weighted average of the breaking-off moments of the currents that is calculated from the formula

$$T_{ABC} = K_1 T_A + K_2 T_B + K_3 T_C,$$

where

T_{ABC} is the common computational breaking-off moment of the currents,

T_A is the breaking-off moment of the current of the phase, in which the current breaks off first,

T_B is the breaking-off moment of the current of the phase, in which the current breaks off second,

T_C is the breaking-off moment of the current of the phase, in which the current breaks off last, and

K_1 , K_2 and K_3 are weighting coefficients.

4. A method as claimed in claim 3, wherein the weighting coefficients of the breaking-off moments of the currents are calculated from the formula

$$K_1 = A_1 (T_B - T_A) / (T_C - T_A)$$

$$K_2 = A_2$$

$$K_3 = A_3 (T_C - T_B) / (T_C - T_A).$$

5. A method as claimed in claim 4, wherein $A_1 = 0.4 - 0.6$, $A_2 = 0.4 - 0.6$ and $A_3 = 0.4 - 0.6$, preferably $A_1 \approx 0.5$, $A_2 \approx 0.5$ and $A_3 \approx 0.5$.

6. A method as claimed in claim 2, wherein the optimum closing moment of the circuit breaker is

$$T_{\text{OPTIMUM}} = T_{\text{ABC}} + n * T,$$

where

T_{OPTIMUM} is the optimum closing moment of the circuit breaker,

n is the number of entire network cycles to lapse from the common computational breaking-off moment T_{ABC} of the phase currents before the circuit breaker is closed, $n = 1, 2, 3, \dots$, and

T is the time of one network cycle.

7. A method as claimed in claim 6, wherein a control command to close the circuit breaker is given at moment

$$T_{\text{ABC}} + n * T - D$$

where

D is the operational delay of the circuit breaker.

8. A method as claimed in claim 1, wherein the electrical network is a three-phase network, the circuit breaker is a single-pole controllable circuit breaker, the currents of all three phases are measured, and the breaking-off moments of the currents of all phases are determined and the circuit breaker is closed in such a manner that in each phase, it closes at moment

$$T_{\text{OPTIMUM}} = T_i + n * t,$$

where

- T_i is the breaking-off moment of the current of a single phase, $i = A, B$ or C ,
- n is the number of entire network cycles to lapse from the breaking-off moment of the phase current before the circuit breaker is closed, $n = 1, 2, 3, \dots$, and
- T is the time of one network cycle.

9. A method as claimed in claim 1, wherein the electrical network is a one-phase network and the circuit breaker is closed in such a manner that it closes at moment

$$T_{\text{OPTIMUM}} = T_i + n * t,$$

where

- T_i is the breaking-off moment of the current of the phase, $i = A, B$ or C ,
- n is the number of entire network cycles to lapse from the breaking-off moment of the phase current before the circuit breaker is closed, $n = 1, 2, 3, \dots$, and
- T is the time of one network cycle.

10. A method as claimed in claim 1, comprising further measuring the voltage of at least one phase, determining a momentary basic frequency of the network on the basis of the measurement of either the voltage or the current, and determining the time of the network cycle as an inverse of the momentary basic frequency of the network.

11. A method as claimed in claim 1, wherein the network component is a transformer, arc suppression coil or any other electrical network component containing a ferromagnetic material.

12. A method as claimed in claim 1, wherein the network component is a capacitor, a compensating capacitor, filter circuit or any other charged electrical network component.

13. A method as claimed in claim 1, wherein the network part is a cable line or network.

14. An arrangement for reducing stress in an electrical network, the arrangement comprising a circuit breaker and the arrangement being arranged to minimize an inrush current caused by a network component or part con-

nected to the live electrical network, the network component or part being arranged to be disconnected from and connected to the live electrical network by opening and closing the circuit breaker, the arrangement further comprising

means for measuring the current of at least one phase of the network component or part,

means for determining the breaking-off moment of the current after the circuit breaker is opened,

means for determining an optimum closing moment of the circuit breaker on the basis of the breaking-off moment of the current, and

means for closing the circuit breaker in such a manner that it closes at the optimum closing moment.

15. An arrangement as claimed in claim 14, wherein the electrical network is a three-phase network, the circuit breaker is a triple-pole circuit breaker, the current is arranged to be measured from all three phases, and the breaking-off moment of the current is one common computational breaking-off moment of the currents of all phases.

16. An arrangement as claimed in claim 15, wherein the common computational breaking-off moment of the currents is a weighted average of the breaking-off moments of the currents that is arranged to be calculated from the formula

$$T_{ABC} = K_1 T_A + K_2 T_B + K_3 T_C,$$

where

T_{ABC} is the common computational breaking-off moment of the currents,

T_A is the breaking-off moment of the current of the phase, in which the current breaks off first

T_B is the breaking-off moment of the current of the phase, in which the current breaks off second and

T_C is the breaking-off moment of the current of the phase, in which the current breaks off last, and

K_1 , K_2 and K_3 are weighting coefficients.

17. An arrangement as claimed in claim 16, wherein the weighting coefficients of the breaking-off moments of the currents are arranged to be calculated from the formula

$$\begin{aligned} K_1 &= A_1 (T_B - T_A) / (T_C - T_A) \\ K_2 &= A_2 \\ K_3 &= A_3 (T_C - T_B) / (T_C - T_A). \end{aligned}$$

18. An arrangement as claimed in claim 17, wherein $A_1 = 0.4 - 0.6$, $A_2 = 0.4 - 0.6$ and $A_3 = 0.4 - 0.6$, preferably $A_1 \approx 0.5$, $A_2 \approx 0.5$ and $A_3 \approx 0.5$.

19. An arrangement as claimed in claim 15, wherein the optimum closing moment of the circuit breaker is

$$T_{\text{OPTIMUM}} = T_{\text{ABC}} + n * T,$$

where

T_{OPTIMUM} is the optimum closing moment of the circuit breaker,

n is the number of entire network cycles to lapse from the common computational breaking-off moment of the phase currents before the circuit breaker is closed, $n = 1, 2, 3, \dots$, and

T is the time of one network cycle.

20. An arrangement as claimed in claim 19, wherein a control command to close the circuit breaker is arranged to be given at moment

$$T_{\text{ABC}} + n * T - D$$

where

D is the operational delay of the circuit breaker.

21. An arrangement as claimed in claim 14, wherein the electrical network is a three-phase network, the circuit breaker is a single-pole controllable circuit breaker, the current is arranged to be measured from all three phases, and the breaking-off moments of the currents of all phases are arranged to be determined, and the circuit breaker is arranged to be closed in such a manner that in each phase, it closes at moment

$$T_{\text{OPTIMUM}} = T_i + n * T,$$

where

- T_i is the breaking-off moment of the current of a single phase, $i = A, B$ or C ,
- n is the number of entire network cycles to lapse from the breaking-off moment of the phase current before the circuit breaker is closed, $n = 1, 2, 3, \dots$, and
- T is the time of one network cycle.

22. An arrangement as claimed in claim 14, wherein the electrical network is a one-phase network and the circuit breaker is arranged to be closed in such a manner that it closes at moment

$$T_{\text{OPTIMUM}} = T_i + n * T,$$

where

- T_i is the breaking-off moment of the current of the phase, $i = A, B$ or C ,
- n is the number of entire network cycles to lapse from the breaking-off moment of the phase current before the circuit breaker is closed, $n = 1, 2, 3, \dots$, and
- T is the time of one network cycle.

23. An arrangement as claimed in claim 14, further comprising means for measuring the voltage of at least one phase, means for determining a momentary basic frequency of the network on the basis of the measurement of either the voltage or the current, and means for determining the time of the network cycle as an inverse of the momentary basic frequency of the network.

24. An arrangement as claimed in claim 14, wherein the network component is a transformer, arc suppression coil or any other electrical network component containing a ferromagnetic material.

25. An arrangement as claimed in claim 14, wherein the network component is a capacitor, a compensating capacitor, filter circuit or any other charged electrical network component.

26. An arrangement as claimed in claim 14, wherein the network part is a cable line or network.